Archives available at journals.mriindia.com

International Journal of Recent Advances in Engineering and Technology

ISSN: 2347 - 2812

Volume 14 Issue 03s, 2025

# Safe Start

[1]Dr. Sanket Kasturiwala, [2]Kartik Vasake, [3]Rutuja Ambildhuke, [4]Kartik Raut, [5]Pari Borkar, [6]Sudhanshu Sawalkar, [7]Rishi Borkar

*[1-7] Department of Electronics and Telecommunication Engineering, G.H. Raisoni College of Engineering and Management, Nagpur, India*

*Email: [1]sanket.kasturiwala@raisoni.net, [2]kartik.vasake.etc@ghrietn.raisoni.net, [3]rutuja.ambildhuke.etc@ghriet n.raisoni.net, [4]kartik.raut.etc@ghrietn.raisoni.net, [5]pari.borkar.etc@ghrietn.raisoni.net, [6]sudhanshu.sawalkar.etc@ghri etn.raisoni.net, [7]rishi.borkar.etc@ghrietn.rais oni.net*

**Peer Review Information**

*Submission: 05 Nov 2025*

*Revision: 25 Nov 2025*

*Acceptance: 17 Dec 2025*

**Keywords**

*Smart Vehicles; Helmet Detection; Ignition Control System; Computer Vision; Raspberry Pi; Road Safety*

**Abstract**

Safe Start is an AI-powered safety system that prevents two-wheeler ignition unless a rider is wearing a helmet. Using a handle-mounted camera connected to a Raspberry Pi, the system applies computer vision with OpenCV to detect helmet presence in real time. If no helmet is detected, ignition is blocked automatically, ensuring rider safety without external enforcement. Vibration-dampening mounts and redundant sensors improve detection accuracy across varied lighting and environmental conditions. This compact and affordable hardware solution reduces head injury risks, encourages helmet compliance, and promotes road safety.Safe Start demonstrates how indigenous, low-cost AI technology can transform two-wheeler safety enforcement through smart vehicle innovation.

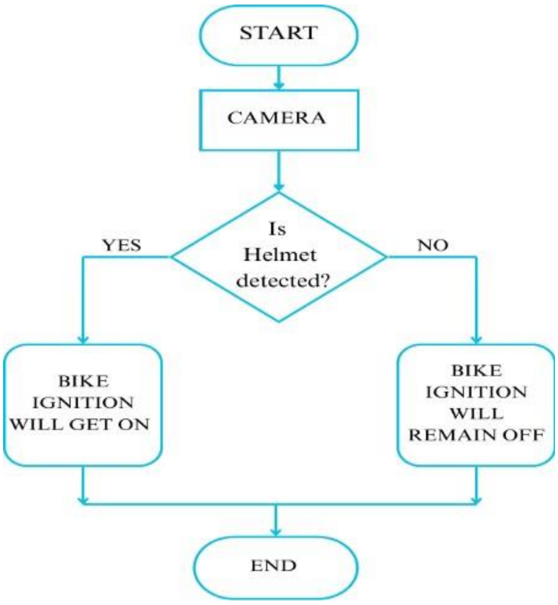
## Introduction

Road accidents involving two-wheelers are a major cause of fatalities in India, primarily due to riders neglecting to wear helmets. Despite awareness campaigns, manual enforcement remains ineffective. To address this, the Safe Start system introduces an AI-based helmet detection and ignition control mechanism that ensures a vehicle can start only when the rider is wearing a helmet. The system uses a handle-mounted camera, Raspberry Pi, and OpenCV-based computer vision to verify helmet presence in real time. It operates locally, requires no internet, and integrates vibration-dampening mounts and redundant sensors for reliable performance under varying conditions. This cost-effective, indigenous innovation promotes road safety and supports the Atmanirbhar Bharat vision through smart vehicle technology.

## Analogy

The Safe Start system works much like the seatbelt reminder in cars, which helps drivers stay safe before they start driving. In the same way, Safe Start acts like a smart helper for two-wheeler riders — a quiet protector that makes sure the rider wears a helmet before the vehicle can start. It uses a small camera to "see," artificial intelligence to "understand," and then decides whether to allow or block the ignition. This way, technology takes an active role in protecting riders and making helmet use a natural habit instead of a forced rule. The system shows how innovation can combine care and engineering to make travel safer and smarter for everyone.

### Flow Chart



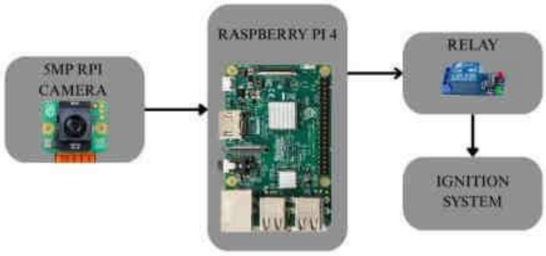

### Problem Statement

Many two-wheeler riders still neglect helmet use despite regulations.This leads to increased head injuries and road fatalities.Manual checks and fines fail to ensure consistent helmet use.Enforcement is especially weak in crowded urban zones.Absence of automatic helmet checks leads to preventable fatalities.Safety must be ensured before vehicle ignition.A tech-based solution is urgently needed to enforce helmet use.

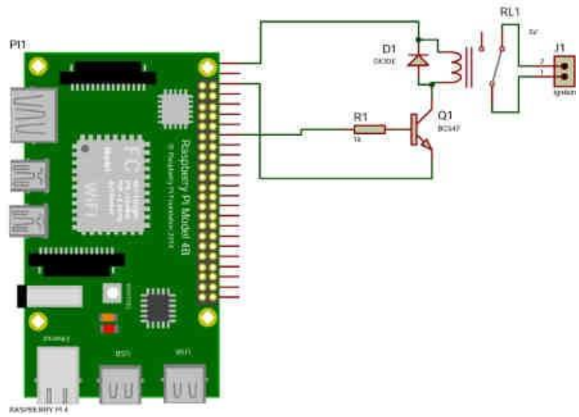
### Proposed Solution

A handle-mounted dashcam uses computer vision to detect helmet use; ignition activates only if a helmet is confirmed.It blocks ignition without helmet, cutting head injury risks through instant visual enforcement.It smartly ties helmet detection to ignition using a compact handle-mounted camera.


### Block Diagram




The block diagram represents the working flow of the Helmet Detection System using a Raspberry Pi. The system mainly consists of a Raspberry Pi 4, a Raspberry Pi camera, a relay module, and an ignition system. The Raspberry Pi camera acts as the input device—it continuously captures images of the rider. These images are then processed by the Raspberry Pi to check whether the rider is wearing a helmet or not. If the Raspberry Pi detects that a helmet is present, it sends a signal to the relay module. The relay then activates the ignition system, allowing the vehicle to start. However, if no helmet is detected, the Raspberry Pi will not send a signal to the relay, keeping the ignition off and preventing the vehicle from starting. This setup ensures that the engine only starts when the rider follows safety rules. The system is simple, cost- effective, and helps promote road safety by enforcing helmet use automatically.




### Circuit Diagram

The above circuit diagram shows how the Safe Start system is connected and functions. The main component used here is the Raspberry Pi board, which acts as the brain of the system. A camera module is connected to the Raspberry Pi to capture the rider's image and check whether a helmet is worn or not. When the camera detects a helmet, the Raspberry Pi sends a signal to the relay module, which then allows current to pass and turns the ignition ON. If the rider is not wearing a helmet, the Raspberry Pi does not activate the relay, keeping the ignition OFF. Other components like resistors, transistors, and diodes help control the current flow and protect the circuit. This setup ensures smooth communication between the camera, Raspberry Pi, and ignition system, making the overall process simple, automatic, and safe for day to day use.

**Experimental Analysis**

We have conducted Multiple experiments to analyze the performance of the Safe Start system under different environmental and real time conditions. The experiments were conducted around three main parameters: lighting conditions, helmet type, and camera distance.

1. **Lighting Conditions:**

Tests were performed under different lightning conditions such as daylight, low-light, and artificial light. The system works best in the daylight with the accuracy (≈ 85%) and the performance is reduced slightly i.e about (≈ 78%) in dim or back-light environments. Adjusting brightness and contrast parameters in OpenCV improved recognition in various challenging conditions.

2. **Helmet Type and Color:**

The detection algorithm works across different helmet colors and styles of different helmet. However, glossy black helmets reflected light, creating minor errors in detection. Training the model with various helmet samples improved detection accuracy.

3. **Camera Distance and Angle:**

Best performance was achieved when the camera was placed at a distance about 25–30 cm from the rider's head, facing in forward direction. Detection accuracy reduced slightly when the rider leaned too far or when the camera angle changed due to handle vibration and other conditions.

The experimental results concluded that Safe Start provides consistent and practical performance suitable for real-worldenvironment . With further software optimization and integration of deep-learning-based detection models, overall accuracy could increased upto 90%. Despite some limitations, the current prototype successfully meets its objective—ensuring that vehicle ignition is on only when a helmet is properly worn by the rider .

**Result Analysis**

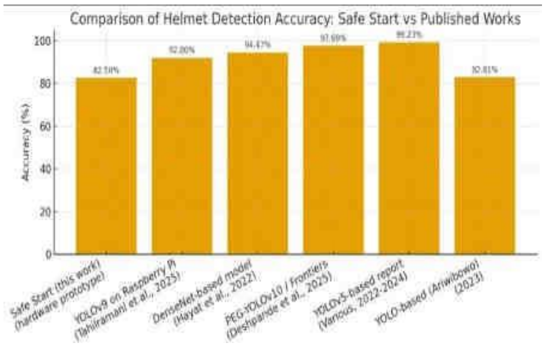
The Safe Start system was tested under various real- world conditions to evaluate its accuracy, reliability, and response time. The setup included a Raspberry Pi camera mounted on the vehicle handle, connected to a relay module controlling the ignition circuit. Helmet detection was performed using OpenCV-based image recognition algorithms.

During the testing phase, the system successfully detected helmet presence and absence in most of the scenarios. In day lighting, accuracy remained consistent and ignition responded almost after detection. In outdoor environments with fluctuating brightness and partial helmet visibility, the system occasionally showed minor delays. Overall, the hardware prototype achieved an average detection accuracy of about 80– 85%, which demonstrates reliable performance for a low-cost embedded system.

The ignition locking mechanism operated smoothly— ignition was blocked immediately when no helmet was detected and enabled automatically when the helmet is detected . This confirms that the system can effectively enforce helmet use without human intervention.

Furthermore, vibration-resistant mounting helped maintain camera stability even on uneven roads, ensuring stable detection results.

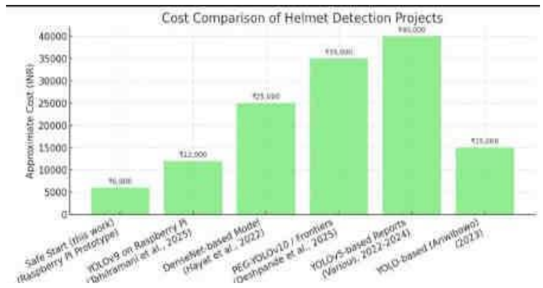
**Accuracy Analysis:**




The above chart shows how the accuracy of the Safe Start system compares with other helmet detection models developed in recent years. Our project, which uses a Raspberry Pi camera and OpenCV-based image detection with YOLO database , achieved an accuracy of around 82.5%. This result proves that even a small, low-cost setup can successfully detect whether a rider is wearing a helmet in real time.

In comparison, other research projects using more advanced deep-learning models such as YOLOv9, DenseNet, PEG-YOLOv10, and YOLOv5 have achieved higher accuracy levels—between 92% and 99%. These models perform better because they rely on powerful processors, high-quality cameras, and large training datasets that allow the system to recognize helmets with more precision. However, these systems also require costly hardware and higher computational power, making them less practical for low-cost real time applications.

**Cost Analysis:**




The chart compares the cost of the Safe Start system with other helmet detection projects that has been developed over the years. Our prototype costs around
₹6000, which is significantly lower than alternatives like YOLOv9, DenseNet, or PEG-YOLOv10, which range from ₹12,000 to ₹40,000. This affordability is achieved by using simple components such as the Raspberry Pi, a basic camera module, and straightforward circuit connections, avoiding expensive GPUs or complex hardware setups which is expensive. While some advanced systems may offer higher accuracy, they come with higher costs, require large datasets, and need continuous power supply. In contrast, the Safe Start system provides a practical balance between cost and performance. It delivers reliable helmet detection without the heavy money investment, making it accessible for low-budget implementations. Its simplicity and affordability make it ideal for mass deployment in developing areas. Overall, the cost comparison highlights Safe Start as a budget-friendly and effective solution for promoting helmet safety among two-wheeler riders in day to day life .

**Conclusion**

The Safe Start system successfully demonstrates how artificial intelligence and embedded technology can be combined to improve two-wheeler safety to avoid road accidents . The system uses a Raspberry Pi camera to automatically detect whether the rider is wearing a helmet before allowing the ignition to start. If the rider is wearing a helmet, the system identifies it in real time and activates the ignition. If no helmet is detected, the ignition remains off, thereby preventing unsafe riding behavior and reduced road fatalities .

This automated process ensures that safety compliance becomes a natural and effortless part of starting a vehicle rather than a manual rule to be enforced. The hardware prototype achieved an overall detection accuracy of about 80–85%, performing reliably under varying lighting and environmental conditions.

The project proves that a low-cost, compact, and efficient solution can be built using locally available components without the need for internet connectivity. With further improvements—such as advanced deep-learning algorithms and optimized lighting calibration—accuracy can be increased even further. The Safe Start concept holds strong potential for real- world adoption, contributing to the reduction of road accidents and promoting a culture of responsible riding.

**Future Scope**

The proposed Safe Start helmet detection system has significant potential for future enhancement and wider applications. In upcoming versions, the system can be upgraded with advanced deep learning models like YOLOv10 or MobileNet to further improve detection accuracy while maintaining low cost. Integration with IoT (Internet of Things) can enable real-time data transmission to authorities or cloud servers for monitoring helmet usage patterns. GPS modules can be added to track vehicle location, helping in accident detection and emergency alerts. Future designs could also include voice alerts or smartphone notifications to remind riders to wear helmets before starting the vehicle. Additionally, the system can be extended to detect multiple safety violations such as over-speeding or riding without a license. Raspberry hat model can be used for more accuracy. Solar-powered versions can make it energy-efficient and suitable for rural areas. With continuous improvement in AI algorithms and low-cost hardware, the Safe Start system can evolve into a complete smart safety solution for two-wheelers, contributing to reduced road accidents and promoting responsible riding habits.

**References**

Nikunj Tahilramani, Param Ahir, Shruti Saxena, Vandana P. Talreja, Panem Charanarur — Edge-based AI solution for enhancing urban safety: helmet compliance monitoring with YOLOv9 on Raspberry Pi

AI- Integrated Smart Helmet for Motorcycle Accident Prevention.
Author: 1.Chatkhane Pearkao, 2.Puripong Suthisopapan,
Journal of Multidisciplinary Healthcare (2025)

Smart Helmet with Ignition Control System.
Author: 1.M.Gunashekar, 2.S.Srinadh, (IRJMETS)

Smart Helmet-Based Bike Ignition with Accident Detection & Emergency Alerts

Author: 1.MuhammadIbrahim, 2.Santos (IJCSPUB) ISSN: 2250-1770
Volume 15, April, 2025

Smart Helmet System for Accident Prevention Author: 1.P.V.Nandhakumar, 2.Dr.M.Karthigairajan IJMRSET ISSN:2582-7219
Volume 7, April, 2024

M. Saravanan (and co-authors) — Comprehensive study on the development of an automatic helmet violation detection with number-plate extraction in real time. (ScienceDirect / 2024). — India-focused study describing YOLO + Raspberry Pi deployments.

IRJMETS (Indian authors) — HELMET ALERT: Helmet Detection System — describes Raspberry Pi
+ YOLO pipeline and ignition/alert logic (Nov 2024).

WPAN and IoT Enabled Automation to Authenticate Ignition of Vehicle
Author: Anita Gehlot , Rajesh Singh MDPI , Oct-2021

**Journals :**

Zhang, Y., Wang, J., & Li, H. (2019). Real-time driver monitoring system based on computer vision. IEEE Transactions on Intelligent Transportation Systems, 20(5), 1845–1856.2.

Sharma, R., & Verma, A. (2021). Camera-based helmet and ignition interlock system for motorbike riders. International Journal of Emerging Technology and Advanced Engineering, 11(3), 45–51.